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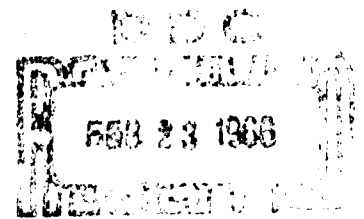


ROYAL AIRCRAFT ESTABLISHMENT
TECHNICAL REPORT No. 65229

**AUTOMATIC
RELEASE POINT
CONTROL EQUIPMENT** [S]

by

M. J. Kempster, B.Sc.



DDC CONTROL
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④ 11 October 1965,

⑫ 25 p.

⑦ AUTOMATIC RELEASE POINT CONTROL EQUIPMENT ⑧ S1.⑩ M. J. Kempster, ~~██████████~~

⑭ TR-65229

SUMMARY

The Automatic Release Point Control Equipment is now used in part of the WE. 177 trials to ensure that the weapon released from a low flying aircraft will impact correctly on a hard target. This paper outlines the need for such a system, the method of operation and some results obtained in early trials.

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1 INTRODUCTION

The development phase of the WE.177 project calls for testing the ability of the parachute retarded store to survive impact with a hard target after release from a low flying aircraft. The target dimensions are to be such that both the first impact and the subsequent impact after bounce occur on the target, but the target size is limited by economic considerations. Hence there is a problem of precisely controlling the release conditions to achieve the required impacts.

The position of the first impact is affected by aircraft flight errors as follows:-

- (a) aircraft speed,
- (b) aircraft height,
- (c) release point,
- (d) aircraft track.

No quantitative information was available on the precision with which these factors could be controlled by a pilot, so a series of evaluation flights were done. These showed that the pilot could control speed and height to the required accuracy but that precision was poorer for track and unacceptable in control of release point.

Therefore I & R Department offered to undertake the task of developing a system which would inhibit release of the aircraft's track was seriously in error, and which would precisely initiate release at the correct release point.

2 THE PROBLEM

The size of the target is determined by factors other than those associated with the release point of the store. The total effect of these errors may be estimated by resolving the individual errors into lengthwise and crosswise components.

2.1 Crosswise errors

Crosswise errors on the impact point are due to:

(a) Wind drift of the store on its parachute. Trials will be limited to conditions in which crosswise errors due to wind drift would be unlikely to exceed ± 60 feet.

(b) Parachute errors due to random functioning in deployment etc. These will cause errors up to ± 50 feet.

The preliminary flying trials showed that the track could be held to within ± 20 feet of the defined line on 90% of the runs. Considering the complexity of designing special equipment to guide the aircraft more accurately than this it seemed reasonable to rely on the pilot to fly the aircraft without artificial aids. However it was obviously desirable to inhibit the dropping of the store if the aircraft was outside the limit of ± 20 feet.

Summing the errors indicates that the target should be at least 260 feet wide at the first impact.

The maximum change of direction after the first impact is expected to be $\pm 5^\circ$. Thus the target should be shaped to accept this disposition.

2.2 Lengthwise errors

The lengthwise errors on the impact point are due to:

- (a) Parachute functioning variations which will contribute up to ± 50 feet.
- (b) Variations in aircraft height. The trials call for drops at 70 feet and 180 feet with height tolerances of ± 20 feet and ± 40 feet respectively. The preliminary flying trials showed that the pilot can achieve these heights within the required tolerances. The lengthwise errors resulting from these height tolerances were calculated to be within ± 70 feet.
- (c) Aircraft speed variations. The preliminary flying trials showed that the pilot was able to maintain the desired speed of Mach 0.85 ± 0.1 with sufficient precision to ensure that no significant lengthwise error results from speed variations.
- (d) Release point errors. The flying trials showed the pilots determination of release point to be highly inaccurate, and errors of the order ± 200 feet were likely.

The necessary target length could be greatly reduced by removing the release point errors. If this is done then a total target length of 840 feet is sufficient allowing for remaining lengthwise errors and a 600 foot distance between first and second bounces.

2.3 The target

A target (Fig.1), was constructed to be slightly larger than the minimum size indicated in the above paragraphs. It has a length of 960 feet and a width at the first impact point of 330 feet fanning out to accept the 5° disposition expected after the first impact.

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2.4 The requirement

From the above analysis the following broad requirement may be stated:

An automatic release point control equipment (A.R.P.C.E.) is to be developed for the definition of a box in the space above the required release point. If the aircraft enters this box correctly, a means of detecting this is required which will trigger the store release system, thus ensuring that impact is achieved within the right limits on the target.

If however the pilot has misjudged his track and the aircraft does not enter the box, it is implied that the impact limits on the target would be exceeded. In this case release is to be withheld.

The system is to function reliably and provide a high degree of security against premature operation.

3 CHOICE OF METHOD

Radio methods were considered insufficiently precise and vulnerable to interference. However optical methods permit sharp definition of the required box and are potentially less susceptible to interference. Two types of optical system were considered:

(a) Detecting the aircraft's presence in the box by a detector on the ground.

(b) The aircraft detecting its own presence in the box.

In type (a) various methods were considered, such as optical sky screens, infra-red detectors picking up jet efflux radiation etc. These methods had the disadvantage of requiring a radio link between the detector and aircraft and were discarded because of the risk of premature operation. Type (b) could be done by wholly optical methods and was therefore preferred.

The method chosen was to have an extended light source on the ground across the flight line at the required release point. This source would project a narrow 'box' of light vertically upwards. The aircraft would carry a photo sensitive device pointing vertically downwards which would detect the light source and so initiate release. With such a system the only possible interfering signals which could cause premature release are those arising from sunlight reflected by the ground or sea. Various methods of discriminating against unwanted background signals are used. These are:-

(a) Intensity discrimination - ensuring that the source intensity is greater than that of reflected sunlight.

(b) Wavelength discrimination - the use of monochromatic light sources and the use of filters in the detector. This method was not pursued since no suitable filters were available.

(c) Waveform discrimination - maximising the response of the detector electronics to the characteristics of the wanted signal.

(d) Highly directive detector - sunlight will be reflected from ground or sea over a wide range of angles. By restricting the acceptance angle of the detector only a limited number of reflected rays can enter it.

There is an optimum size for the detector acceptance angle which is related to the size of the ground light source.

3.1 The ground light source (See Figs.2 and 3)

The maximum allowable track error at release is ± 20 feet and so the width of the 'box' to be defined in the sky is 40 feet. The maximum allowable error along the flight line is ± 50 feet but the length of the 'box' may be of any convenient smaller size. Thus a single line of vertically pointing lamps may be used to produce a 'bar' of light 40 feet wide.

A detector with a small acceptance angle is desirable and so the ground light source need only have a small beam angle. This enables a higher light intensity to be achieved for a given electrical power.

For releases in the different height bands the position of the ground lights must be changed. Therefore the light source must be movable and easily set up.

The most suitable lamp examined was the Phillips P.A.R.38, 24 volts, 150 watt spotlight. The beam half angle is 5 degrees and the axial intensity 25000 candelas. The reflector diameter is $4\frac{3}{4}$ inches and 81 units mounted 6 inches between centres form the bar of light 40 feet long. For ease of handling 27 units were mounted in each of three gantries which are placed end to end. The gantries are fitted with wheels, handles, levelling jacks and transformer. The lamps on the outer gantries are tilted 5 degrees inwards to make the edges of the beam vertical.

3.2 The photosensitive device

The detector consists of a photosensitive device mounted in the focal plane of a telescope. To give the greatest difference between the signals from the ground lights and background signals the photosensitive area should be completely covered by the image of the ground lights when the aircraft is overhead. The size of the image of the bar of lights will depend on the focal length of the telescope lens and its angle of acceptance.

The lens chosen was an achromatic doublet of 5.2 cm diameter and 15 cm focal length. This had adequate light gathering power and gives a telescope of convenient size.

The image on the focal plane of this telescope when the aircraft is at its lowest height (50 feet) over the lights will be a bar 0.15 cm wide. The optimum width for the sensitive area is therefore 0.15 cm and if the speed of the aircraft is 1000 ft/sec the area will be illuminated for a total time of 6.5 milliseconds.

Therefore the photocell selected should have adequate sensitivity for the light available, should have a response time constant of the order of 0.5 milliseconds, and have a physical size only 0.15 cm wide.

The cell best filling these requirements was the Texas Photo-Duo-Diode 1S701. This may be considered as a resistance that changes from 5 M/ohm to 2 K/ohm when illuminated in the conditions described. The sensitive area of the cell is covered by a small hemispherical lens 0.18 cm in diameter. Three of the cells are mounted in parallel to give a sensitive area roughly rectangular to match the shape of the image of the lights. This gives the telescope an acceptance angle of $2/3$ degree along the flight line and 2 degrees across the flight line.

3.3 Control unit

The store is released from the aircraft by operating a relay in the release line. This relay is controlled by a circuit which causes the relay to operate when the resistance of the photocells falls below a certain value.

The circuit used is shown in Fig.4 and is essentially an emitter follower controlling the firing of a silicon controlled rectifier. The photocell resistance at which the S.C.R. is turned on depends on the value of R_1 , this giving a method of adjusting the sensitivity.

The power supply to the circuit is from the aircraft's 28 volt d.c. supply, smoothed to guard against operation due to spurious pulses from the supply. The circuit will not respond to slowly changing signals and thus gives protection from certain types of background signals.

3.4 Interconnection with the release system

A simplified diagram of the release system is shown in Fig.5. The explosive release of the store is initiated by closing the release relays

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R₂ and R₃. The pilot closes the bomb master switch S₁ and squeezes the trigger S₂ a few seconds before reaching the release point but the release of the store is delayed until the A.R.P.C.E. operates, closing the relay R₁.

To increase the overall safety of the system the A.R.P.C.E. is not made sensitive until the pilot closes the bomb master switch S₁. Controlling the power to the A.R.P.C.E. by the bomb master switch also reduces the number of pilot actions in the few seconds before release.

4 EXPERIMENTAL VERIFICATION OF CHOSEN METHOD

4.1 Ground trials

Before the A.R.P.C.E. was installed in an aircraft, flying conditions were simulated on the ground. Pulses of light were reflected into the telescope from a rotating mirror. The light source consisted of a battery of the selected lamps placed at distances equal to the specified operating heights. The speed of rotation of the mirror was adjusted to give light pulses on the focal plane of the telescope of duration equivalent to the light pulses expected for the various aircraft speeds.

The performance of the A.R.P.C.E. was assessed from the ground trials and the sensitivity of the control unit adjusted to give reliable operation at the greatest specified height.

4.2 Preliminary air trials

The preliminary air trials were carried out with the aim of proving the operational reliability and safety of the system. The Llanbedr Meteor WH 309 was chosen for the trials and the equipment was built into the front of the port wing tip camera pod (see Fig.6).

For these trials the A.R.P.C.E. switched on a tungsten iodine lamp mounted in a perspex dome on the front of the pod. (Fig.7.) This light was photographed from the ground and enabled the position of simulated release to be determined.

The signals from the telescope to the control unit were monitored by two analogue channels of the ANTAFf telemetry system. One channel of high gain was used to record low level background signals while the other channel of low gain was used to monitor the size of the signals from the ground lights.

4.3 Results of trials with Meteor

4.3.1 Blind sortie

For the first sortie mounted the telescope was fitted with a lens cap to exclude light from the photo sensitive cells. Thus, any signals recorded would be due to electrical interference from equipment inside the aircraft or to vibration effects. No such signals were observed and this indicated that the performance was adequate in these respects.

4.3.2 Background trials

Two sorties were mounted, totalling about $1\frac{1}{2}$ hours in bright sunny conditions, to investigate the size of background signals. The equipment was kept sensitive for the whole time and no simulated release (illumination of the lamp) was observed.

The telemetry results proved to be unreliable due to signal fade and drift. However the results would have shown any signal greater than one fifth of the required firing level. No such signals were observed.

4.3.3 Functioning and inhibition trials

The A.R.P.C.E. should initiate a release when the aircraft's position over the ground lights is correct and should inhibit if the aircraft's position is incorrect. To test this capability the aircraft's height, line and angle of bank on successive runs was varied. To determine whether or not the telescope had 'seen' the ground lights on a given run the aircraft was photographed from beam and line by high speed cine camera. The results obtained were:

Height ft	Total No. of runs	Expected functions			Expected inhibitions		
		Total	Correct operations	Failures	Total	Correct operations	Failures
70 \pm 20	52	34	34	0	18	18	0
180 \pm 40	24	13	13	0	11	11	0
Above 220	2	1	1	0	1	1	0

4.4 Conclusion

During the background trials worst conditions were sought and the equipment was sensitive for a long time. Thus the chances of an inadvertant release in the few seconds before the release point is reached in the dropping trials is small.

The functioning trials showed that the system worked reliably when the telescope 'saw' the ground lights.

The installation on the Meteor was structurally limited to a maximum airspeed of 300 knots. The maximum speed called for in the specification is 600 knots and so further tests at this speed were required. These tests were done on the first Scimitar aircraft to be fitted with A.R.P.C.E. for store dropping purposes.

5 FITTING AND PROVING THE A.R.P.C.E. IN THE WE.177 TRIALS AIRCRAFT

The aircraft to be fitted with the A.R.P.C.E. for the WE.177 proving trials were the Scimitar, Canberra and two Buccaneers. The equipment in each case was similar although the installation details varied.

5.1 Scimitar proving trials

The A.R.P.C.E. equipment for Scimitar XD.229 is shown in Figs.8, 9 and 10. This installation replaces an existing panel in the belly of the aircraft.

With the aircraft jacked into its nominal flying altitude the inclination of the panel to the horizontal was measured. This attitude was reproduced on the bench and the telescope adjusted in its gimbals to make the optical axis vertical. The sensitivity of the control unit was adjusted as described in 4.1.

For the proving trials the equipment suppressed a radio release tone when triggered. This cessation of R.R.T. initiated the firing of a flash bulb on the ground. The position of the aircraft when the flash bulb fired was recorded photographically.

5.1.1 Background trials

Three sorties were flown in bright weather to give a total sensitive time of about one hour. It was not possible to measure actual signal levels but no inadvertant release occurred.

5.1.2 Functioning trials

The runs were made at various heights and speeds and the results are as shown:

Height and speed	Total No. of runs	Expected functions			Expected inhibitions		
		Total	Correct operations	Failures	Total	Correct operations	Failures
70 \pm 20 ft } 300 knots }	15	15	15	0	0	0	0
70 \pm 20 ft } 600 knots }	16	16	15	1	0	0	0
180 \pm 40 ft } 300 knots }	22	21	12	9	1	1	0
180 \pm 40 ft } 600 knots }	17	17	17	0	0	0	0
Above 220 ft	11	6	6	0	5	5	0

The table shows that the equipment failed to operate correctly on ten occasions. However the nine failures at 180 feet and 300 knots all occurred in one sortie because some of the dirty oil on the belly of the aircraft had covered the telescope window. The failure at 70 feet and 600 knots was put down to the obscuring effect of a condensation pattern seen to form on the shock wave from the aircraft as it passed over the lights.

Thus the installation on the Scimitar appeared to function correctly and safely.

5.2 Canberra proving trials

The most suitable mounting site for the A.R.P.C.E. in Canberra WT.309 was the rear camera bay. The telescope in its gimbals was installed over the camera window and, because of the greater space available, it was possible to align the telescope in place with the aircraft in its flying attitude. The control unit sensitivity was adjusted as before.

In this aircraft it was possible to monitor and record the signal from the telescope. A battery operated oscilloscope mounted in the nose of the aircraft monitored the signal while an MU7 tape recorder recorded the signal, radio release tone and the aircraft's R.T.

5.2.1 Background trials

Various lit backgrounds were flown over at appropriate heights while the signal from the telescope was recorded. When reading out the tapes it was possible to correlate a signal to a certain type of background by the commentary recorded on a separate track.

The largest background signal was found to come from bright sunlight reflected from a white painted area on the airfield. This signal proved to be only one thirtieth of the signal needed to cause a release.

The signals from sunlight reflected from ruffled water were investigated and proved to be very low due to the oblique angle of the sun's rays and the telescope's narrow field of view.

5.2.2 Functioning trials

The procedure for evaluating the functional reliability of the A.R.P.C.E. in the Canberra was similar to that used for the Scimitar installation. The results of 30 passes over the lights indicated that the system functioned correctly.

5.2.3 Conclusion

The Canberra installation worked reliably and was not sensitive to background signals. However due to the geometry and size of the aircraft it was difficult to fly accurately enough to be certain of correct operation on every run. A considerable amount of pilot familiarisation will be a necessary preliminary to store dropping trials with this aircraft.

5.3 Buccaneer installation

The A.R.P.C.E. was installed in a compartment behind the weapon bay of the aircraft. Again it was possible to adjust the telescope with the equipment installed and the aircraft in flying attitude.

At the time of writing the equipment had been ground tested successfully but no flying trials had been attempted.

6 RESULTS OF STORE DROPS ON THE HARD TARGET

At the time of writing the A.R.P.C.E. has been used to drop five stores successfully. The results of the drops are shown below.

Aircraft	Height	Speed	Lengthwise error	Crosswise error
Scimitar	140 feet	365 knots	37 feet	16 feet
Scimitar	550 feet	610 knots	48 feet	15 feet
Scimitar	200 feet	600 knots	110 feet	118 feet
Canberra	310 feet	300 knots	1½ feet	10 feet
Scimitar	210 feet	650 knots	10 feet	2 feet

As the proving of the A.R.P.C.E. was being completed the height specification was changed to a maximum height of 550 feet. This change necessitated a small change in the sensitivity of the control unit after which the equipment worked satisfactorily over the whole height range. Before store dropping from these greater heights a large amount of pilot familiarisation is needed.

7 CONCLUSION

The A.R.P.C.E. met the requirement of releasing the store at the correct point on the flight line and preventing release if the flight track was in error with respect to the target. The system functioned satisfactorily up to the specified maximum height of 220 feet. Subsequently it was modified to enable a maximum release height of 550 feet to be used.

8 ACKNOWLEDGEMENTS

The writer would like to acknowledge the help received from Target Development and Photographic Sections, Llanbedr, Electronics and Photographic Sections, West Freugh and Weapons Department, Farnborough.

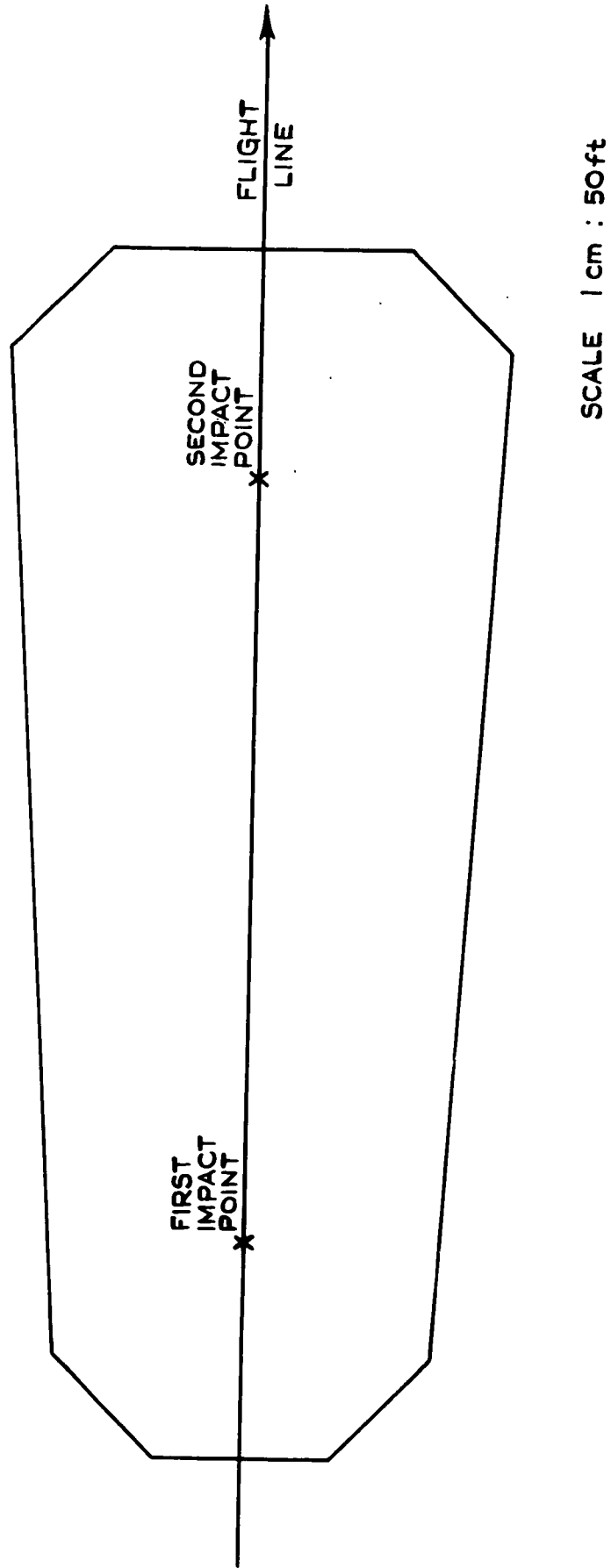


FIG.1 THE TARGET

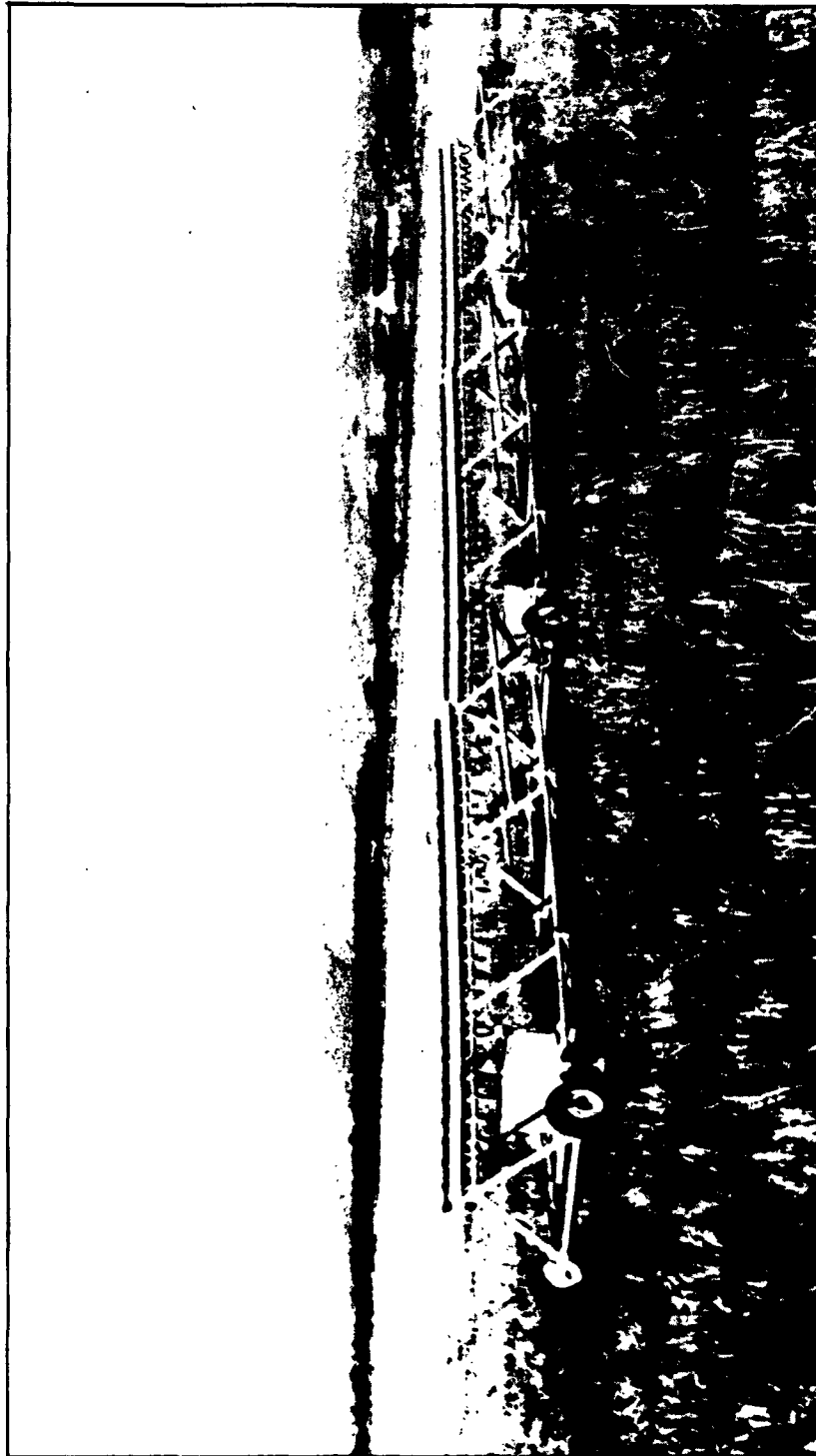


Fig. 2 Ground light source

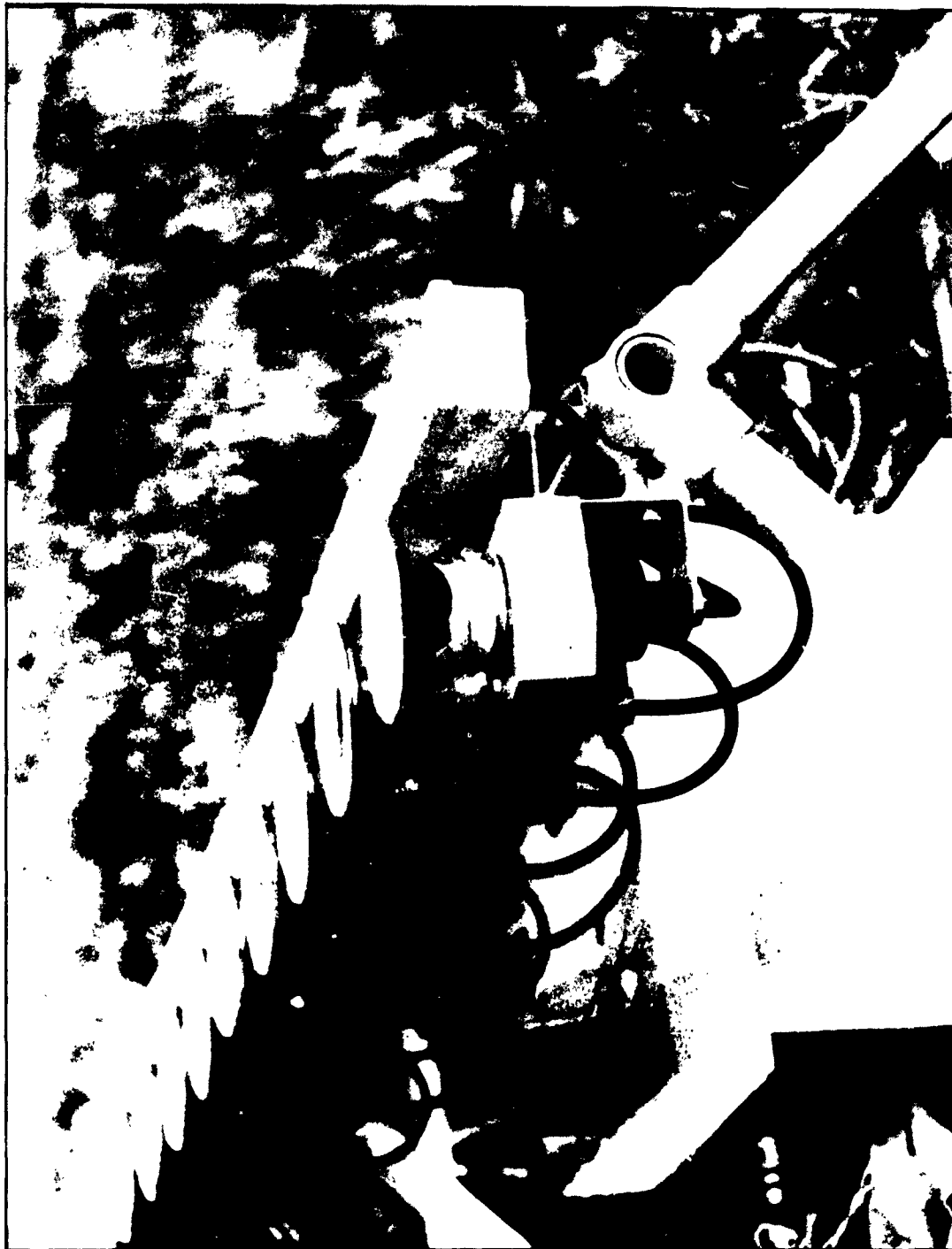


Fig. 3 Ground light source - Detail

Fig.4

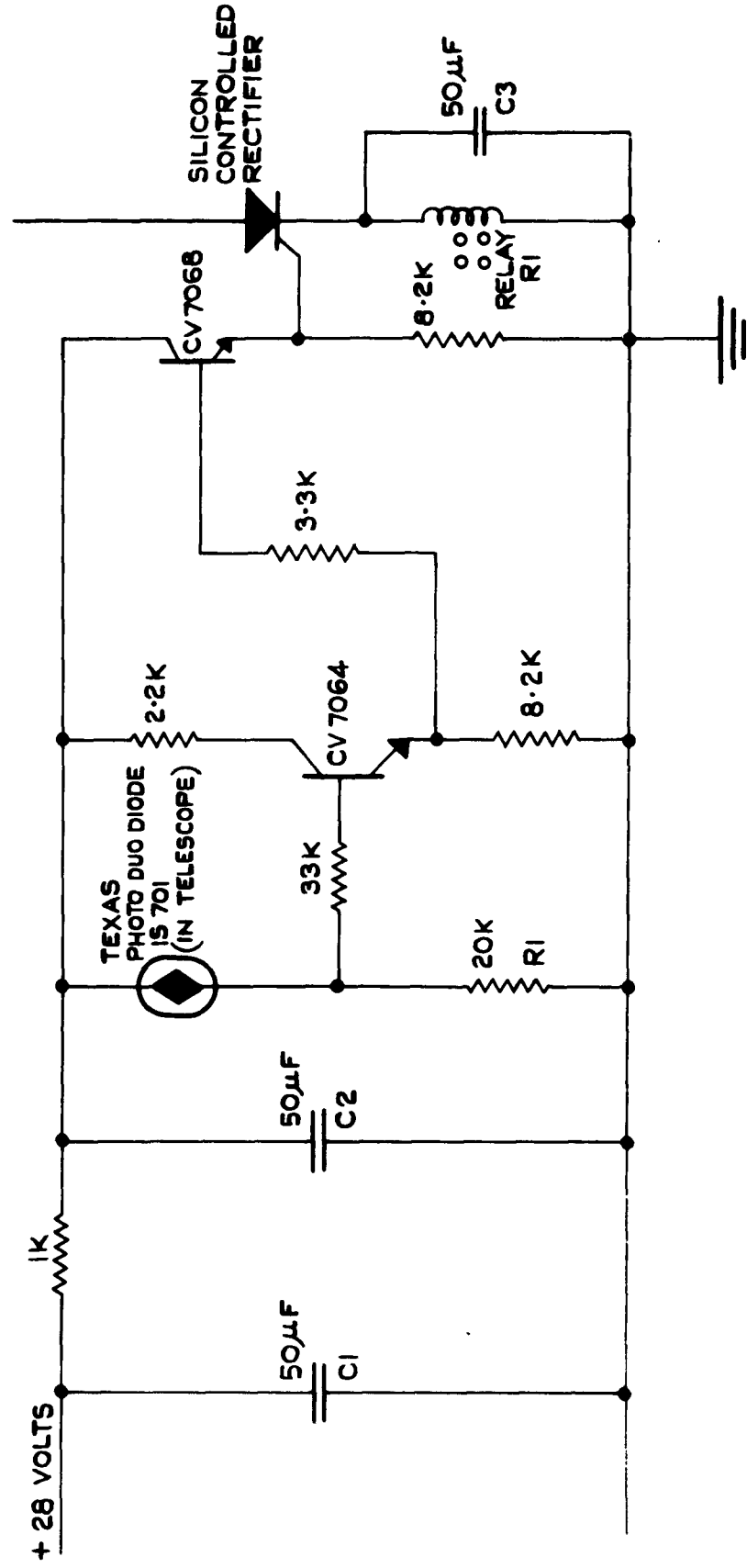


FIG. 4 CIRCUIT DIAGRAM OF CONTROL UNIT

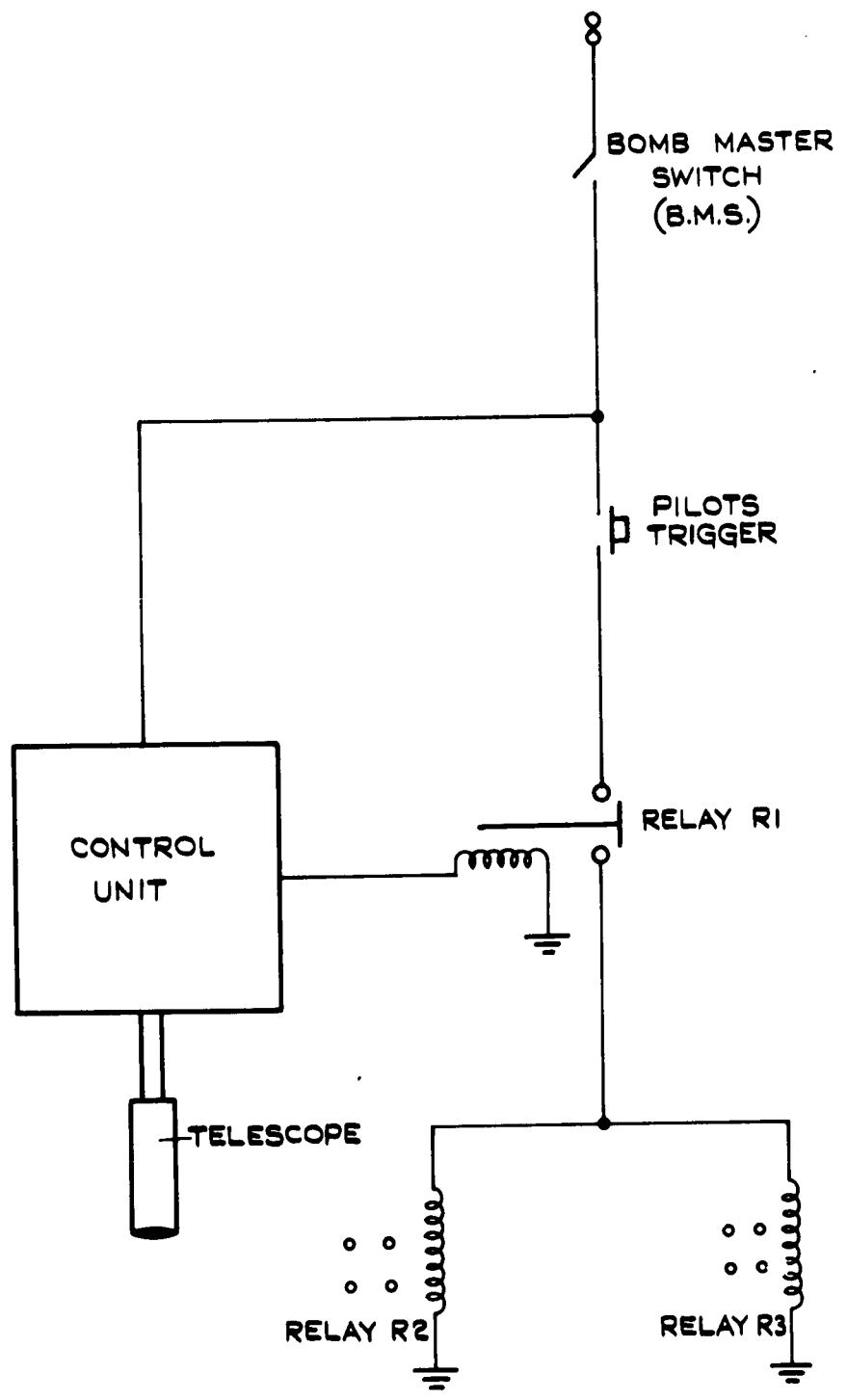


FIG.5 SIMPLIFIED DIAGRAM OF THE

Fig.6

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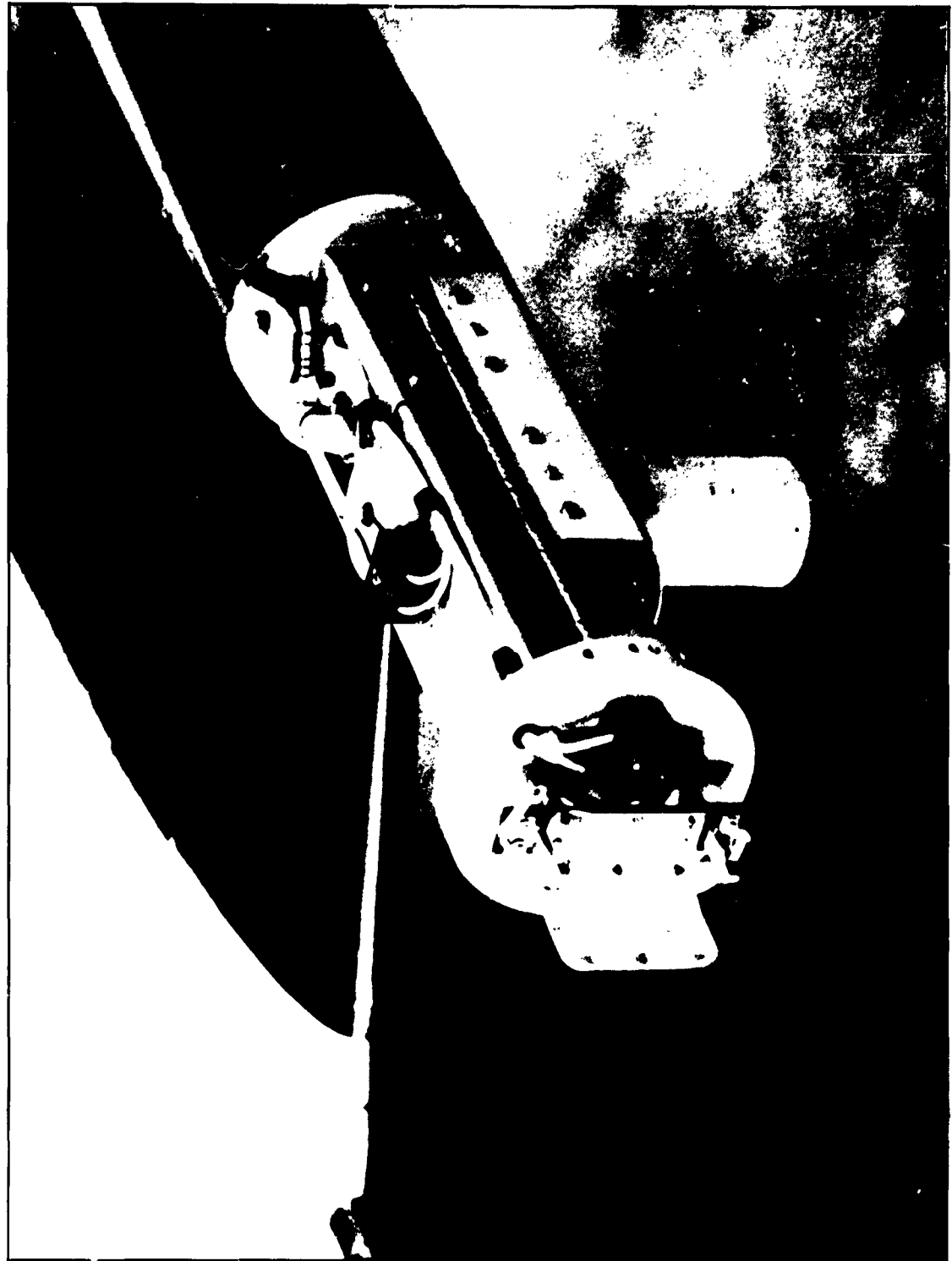


Fig. 6 A.R.P.C.E. installation in port wing tip of Meteor WH 309

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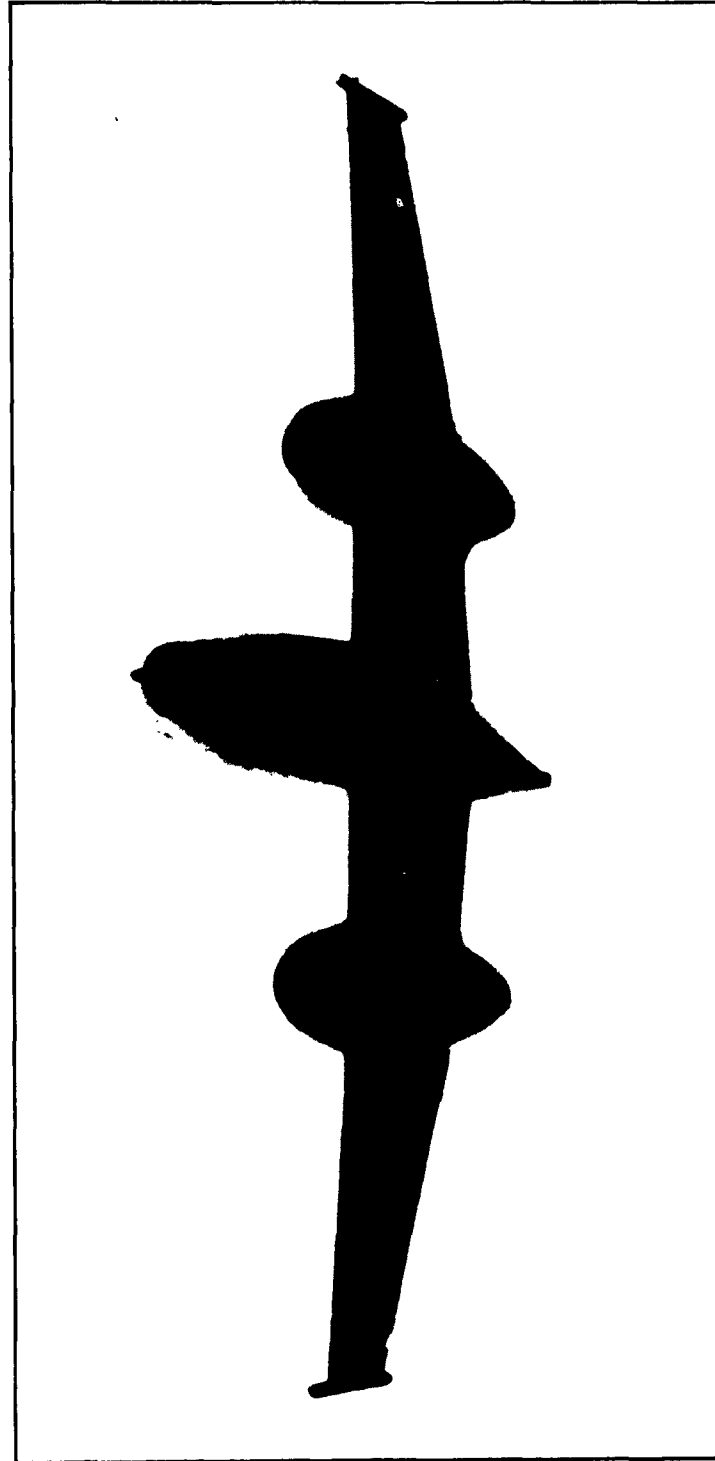


Fig.7 Lamp in port wing tip switched on to simulate release

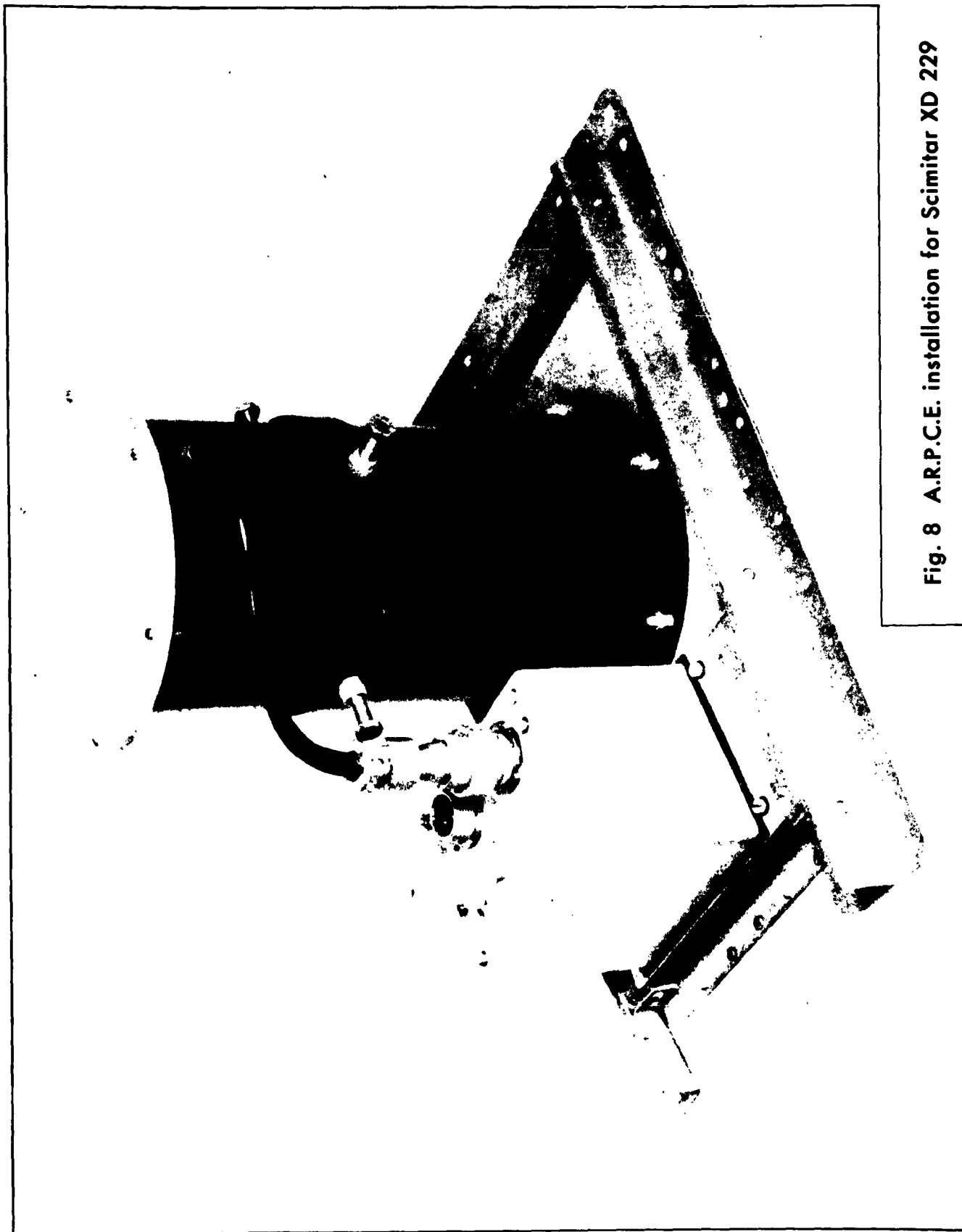


Fig. 8 A.R.P.C.E. installation for Scimitar XD 229

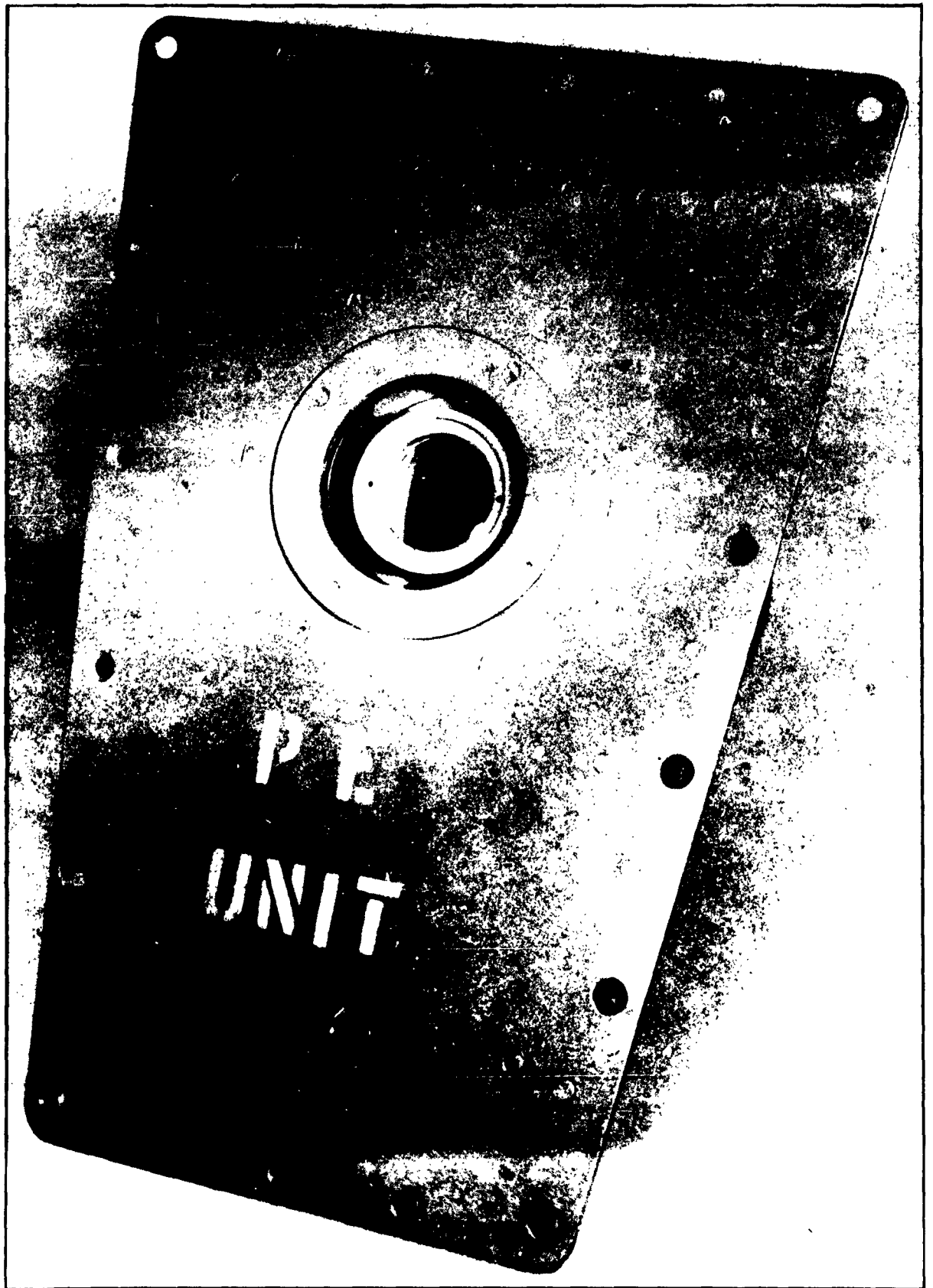


Fig. 9 A.R.P.C.E. panel for Scimitar XD 229

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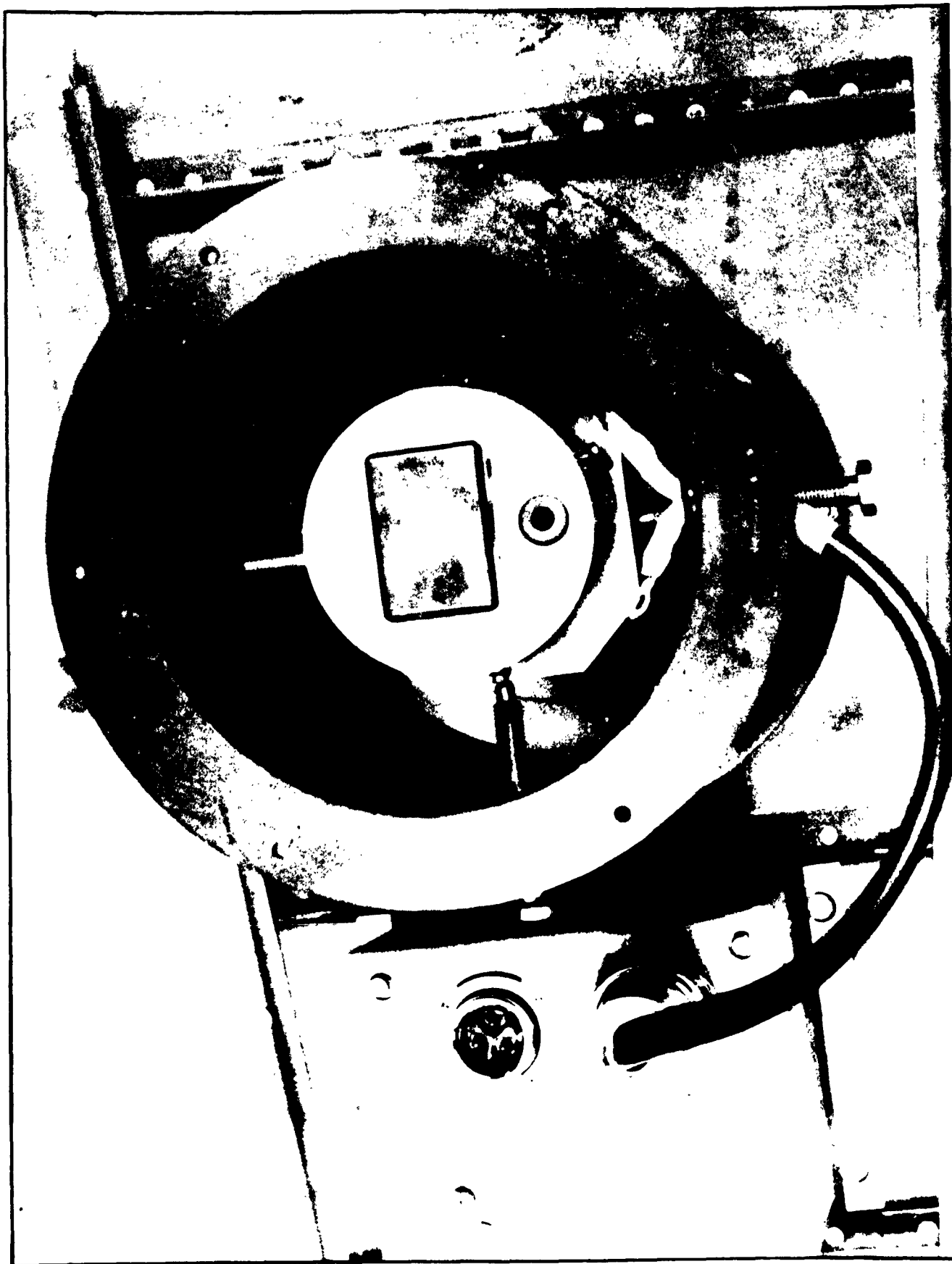


Fig. 10 Detail of Scimitar installation showing telescope gimbals

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